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Publication No. 83-e07

WA-24-2010

STATE OF WASHINGTON

# DEPARTMENT OF ECOLOGY

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MEMORANDUM
January 17, 1983

Howard

To: ~~Frank Monahan~~

From: Dale Clark DC

Subject: Raymond/South and North Fork Willapa River Fecal Coliform Survey

During March, April, and May of 1982 the Department of Ecology (WDOE) Water Quality Investigations Section conducted a survey on the south fork, north fork, and part of the main channel of the Willapa River at Raymond, Washington. The purpose of the survey was to determine if raw sewage discharges from the City of Raymond sewage treatment plant (STP) are degrading the water quality of the Willapa estuary. The survey included sampling at the sewage discharge, upstream and downstream from the discharge on the south fork of the Willapa River, upstream and downstream from the confluence of the south fork with the north fork of the Willapa River, and a sanitary survey for other potential sewage sources along the river banks of the area. Fecal coliform contamination was the major factor investigated.

Fecal coliform (FC) bacteria are found in the intestinal tract of all warmblooded animals and are excreted along with fecal waste material. FC bacteria are capable of surviving in streams, rivers, lakes, estuaries, and other bodies of water for a long period of time and are useful in evaluating the extent of contact between fecal material and a receiving water. Due to the positive correlation of FC bacteria to fecal matter, it is reasonable to assume that when the bacteria are present in a water sample at a sufficiently high level, that the sample is contaminated by fecal material from a warmblooded animal including domestic or wild animals, or humans. The source for this material may include: (1) failed or damaged septic systems or drainfields that can act indirectly (groundwater leaching or runoff) or directly (point-source input) as a link between human activity and receiving water; (2) access to receiving waters by domestic livestock either directly by lack of fencing or other protection, or indirectly through the leaching of groundwater that creates a condition in which contamination may occur; or (3) contamination created by direct contact that results from habitat and behavior characteristics of waterfowl and other wild animals.

## Description of Study Area

The study area is located in close proximity to the confluence of the north (main) and south forks of the Willapa River (river mile [R.M.] 7.2) in the southwest corner of Washington State (Figure 1). The City of Raymond is located at the confluence and operates a sewage collection system that discharges at R.M. 1.0 on the south fork. The river system drains a land area totaling 258 square miles and empties into Willapa Bay, a major estuary on the Washington coast (USGS, 1979). Tidal influences from the estuary affect the study area and create flow reversals during flood tides in the river channels.

A study conducted in 1981 for WDOE by $CH_2M$ Hill, a Seattle-based consulting firm, named the Willapa River as a large contributor of municipal, industrial, and food processing wastes to the estuary. One source of FC contamination located during the study was the Raymond STP. The STP receives wastewaters from a combined sewer that serves the community. During 1980, the plant discharged an average of 0.156 million gallons per day of treated effluent. Fecal coliform samples collected on a bi-weekly basis registered counts ranging from 3 org/100 mL to "too numerous to count" (over 1,600 org/100 mL) ($CH_2M$ Hill, 1981). Fecal coliform loads from the plant were not calculated due to the wide ranges in both plant flow and fecal coliform counts that coincided with relatively low numbers of samples collected, factors that would have made the figures unreliable (ibid). Since January 1982, the plant has been out of service due to mechanical failure and sedimentation buildup in the clarifier (Neel, 1982). Wastewater from the Raymond sewer system has been discharged to a ditch adjacent to the plant and allowed to flow untreated into the south channel, resulting in a potential increase of fecal coliform loading to Willapa Bay.

Willapa Bay contains many areas used for the commercial growing of Pacific oysters (*Crassostrea gigas*). Pollution from various sources including fecal coliform contamination from human activity jeopardize such areas and result in the closure of oyster beds (Clark, 1981). Willapa Bay is designated as a Class A marine water with shellfish growing as a protected beneficial use. For human health reasons, stringent limits are placed on levels of fecal coliform bacteria in oyster tissue marketed for human consumption (230 org/100 gm). In order to achieve this limitation in oyster tissue, FC levels in growing waters (Class A) are strictly regulated (see Results, page 5 for state water quality standard). Levels even slightly above the regulatory standard can result in FC tissue burdens exceeding market limitations (Clark and Determan, 1981). This is mainly due to the filtering efficiency of the oysters in removing bacteria and other micro-organisms from the surrounding waters. For this reason, there is a great deal of concern when point sources such as the Raymond raw sewage discharge create conditions where the potential for increased FC loading to commercial shellfish growing areas exists.

There are several factors that contribute to whether or not the fecal coliform load from a point source located on a stream will be significant to degrade water quality downstream from the source. These factors include:

1. Fecal coliform load from the point source. Fecal coliform loading is defined as the concentration found in a water sample times the total calculated flow per day times a constant. The daily loading is used as a method of assessing the percentage of the total loading to a receiving water from various point and background sources. Often a point source that demonstrates high FC counts will appear to be a significant contributor when in fact the percentage of total loading from the source will be insignificant due to low flow rates. The opposite of this phenomenon may also be observed.

2. Receiving water volume. Dilution of FC loads by large volumes of water may result in fecal coliform counts dropping to within receiving water regulatory limits.

3. Fecal coliform dieoff rates in a receiving water. Since fecal coliform bacteria live and reproduce almost exclusively in warm-blooded animals, upon contact with receiving waters they begin to die off. The longer the contact period, the greater the dieoff. Marine waters create conditions non-conducive to FC survival. In a system such as that found in the Willapa River from Raymond to the Bay, both factors are found and may result in significant, rapid dieoff of the bacteria.

   It should be noted that any contact of human and other animal waste with waters used for the production of shellfish may be significant since these organisms can concentrate bacteria. Contact from numerous sources, even small ones, could result in shellfish tissue levels exceeding FC regulatory limits.

## Methods

Four field trips were conducted during the sample collection phase of this survey. Sampling was limited to those parameters that would satisfy the primary goal of assessing the impact of fecal coliform loading from the Raymond raw sewage discharge on the Willapa estuary. The following parameters were included in the surveys when deemed necessary for assessing FC contamination:

1. Fecal Coliform (org/100 mL). Samples were collected in sterilized bottles and returned to the WDOE microbiology laboratory located at the Southwest Regional Office in Tumwater for analysis using the Membrane Filter (MF) technique (APHA, *et al*., 1977).

2. Dissolved oxygen (D.O.) (mg/L). Some D.O. samples were taken to aid in predicting localized impacts of sewage discharge. Laboratory analysis using the azide modification of the Winkler titration method was used (APHA, *et al.*, 1977).

3. Salinity (o/oo). Salinity values were measured in the field to aid in determining mixing and percentage of saltwater from tidal influence in the survey area. A Beckman salinometer was used to measure salinity in-field.

4. Temperature (°C). Measurements were taken as a general water quality measure.

The field trips were designed to carry out specific aspects of the survey and included the following:

1. April 13, 1982 (Flood Tide Sampling). The first field trip was carried out during flood tide conditions in order to characterize mixing and dispersion of the effluent as it was carried upstream from the discharge. At the point of egress from the sewage discharge ditch, 500 mL of fluorescent dye (Rhodamine WT) was added to the effluent stream. The dye was followed upstream by boat; sampling occurred periodically in the leading area of the dyed waste stream.

2. April 21, 1982 (Ebb Tide Sampling). The second field trip was similar to the first and was carried out during a greater ebb tide to determine mixing characteristics downstream from the discharge.

3. May 3, 1982 and May 24, 1982 (Quarter-point Sampling). Sampling began one hour prior to low tide so that the river would have had sufficient time to flush waters influenced by tide reversal from the study area. This flushing time was necessary so that collected water samples would provide an accurate measure of background levels and subsequent inputs of FC bacteria into the river system. Stations were selected upstream and downstream from the discharge at strategic points (bridges, piers, dolphins, etc., Figure 3) and samples (usually three) were collected at equal distances across the stream channel. These data were used to calculate FC loading from the Raymond STP bypass and to determine if fecal coliform levels in the main channel were significantly raised by levels in the south fork which receives FC input from the Raymond discharge. If elevated levels in the main fork could be related back to the discharge, it may indicate that the discharge is influencing the loading to Willapa Bay.

## Results

To aid in reviewing results, the Washington State water quality standards for fecal coliforms and dissolved oxygen in Class A (excellent) waters, as given in the 1977 WDOE publication entitled, "Laws and Regulations" are:

General considerations:

1. At the boundary between waters of different classifications, the water quality criteria for the higher classification shall prevail.

2. In brackish waters of estuaries, where the fresh- and marine water quality criteria differ within the same classification, the criteria shall be interpolated on the basis of salinity; except that the marine water quality criteria shall apply for dissolved oxygen when the salinity is one part per thousand or greater ($\geq$ 1 ppt) and for fecal coliform organisms when the salinity is ten parts per thousand or greater ($\geq$ 10 ppt).

Fecal Coliform Organisms:

Freshwater - Fecal coliform organisms shall not exceed a median value of 100 organsims/100 mL, with not more than 10 percent of samples exceeding 200 organisms/100 mL.

Marine Water - Fecal coliform organisms shall not exceed a median value of 14 organisms/100 mL, with not more than 10 percent of samples exceeding 43 organisms/100 mL.

Dissolved Oxygen:

Freshwater - Dissolved oxygen shall exceed 8.0 mg/L.

Marine Water - Dissolved oxygen shall exceed 6.0 mg/L, except when the natural phenomenon of upwelling occurs. Natural dissolved oxygen levels can be degraded by up to 0.2 mg/L by man-caused activities.

Results compiled from the four surveys indicate that fecal coliform counts exceeded the Washington State water quality standard (WDOE, 1977) for freshwater in 32 of the 46 total receiving water samples and 24 samples (52 percent) exceeded 200 org/100 mL. The south fork (Figures 1 through 3) sampling stations displayed 22 out of 25 samples exceeding the freshwater criterion with 19 of the samples (61 percent) exceeding 200 org/100 mL.

Using Rhodamine WT dye, surveys 1 and 2 demonstrated that the Raymond sewage was poorly mixed for 300 yards upstream from the discharge during a flood tide (7.8 feet) and for 2,500 yards moving downstream during an ebb tide (0.7 foot) in the south fork. Observations during both surveys indicated that the waste stream remained close to the bank where the effluent was discharged. Samples taken from the far shore displayed fecal coliform counts much lower than that found in the mixing zone (April 13, 1982 #4, April 21, 1982 #5) (Table 1) although still exceeding the water quality criteria.

Review of FC and salinity data for the entire survey period suggests that the Willapa River FC loading to Willapa Bay is not substantially increased by raw sewage point sources on the south fork (Table 1). This agrees with $CH_2M$ Hill which pointed out in a sanitary survey of Willapa Bay and River Inputs published in 1982 that even though the Willapa River was a major contributor of FC loading to the northern bay, that dilution by ocean water and time of travel resulted in no apparent effect on water quality at commercial oyster beds in the estuary. The apparent mechanism for the observed dropoff in FC levels along the lower river mainstem is increased salinity as a result of tidal exchange, wind-driven turnover, and mixing in the main channel. FC bacteria are sensitive to many environmental factors including light intensity, salinity, and temperature. Population stability of FC bacteria in raw sewage can be markedly affected by these factors. $T_{90}$ (time for 90% reduction in population) for FC bacteria in the presence of seawater and sunlight was found to be from 30 to 90 minutes. However, for seawater held in darkness FC populations could remain activated up to four days (Fujioka, R.M., et al., 1961).

During the survey, FC samples collected on the mainstem downstream from the confluence with the south fork demonstrated reduced concentrations (org/100 mL) and increased salinities (o/oo) when compared to samples collected upstream in both forks of the Willapa (Table 1 surveys #3 and #4). Further study would be required to fully document the reduction since large variations in FC populations and salinity are considered to be the norm in this rapidly changing system. Strict interpretation of violations under these dynamic conditions is not recommended ($CH_2M$ Hill, 1981). FC concentrations in the north fork also demonstrated wide variations in concentration during surveys 2-4 (Table 1).

FC concentrations in samples taken below the Raymond discharge ditch (Fig. 1) on the south fork demonstrated a marked increase over samples collected above the discharge. Many of the FC samples collected were clearly in violation of Class A water quality standards (Table 1, surveys 1-4). However, with the exception of survey #4 (Table 1), main channel samples remained generally below or close to the standard.

High concentrations of fecal coliforms were noted for all stations during survey #4 (Table 1) with the exception of sampling changes for station one and the raw sewage outfall sampling was identical to survey #3. All of the stations sampled in both surveys displayed an increase in FC concentrations by a factor of ten during survey #4. Often changes in river flow as a result of increased rainfall will generate higher FC counts due to increased runoff from farmlands and other areas where domestic animals are kept. However, during May of 1982 only slight precipitation (0.5") was noted for the entire month (U.S. Weather Service, Olympia). Further study would be required in order to determine the cause of the overall FC increase observed in the system. It should be noted that rapid declines in FC concentrations were noted at stations downstream in the main channel (Table 1, R.M. 7.0, R.M. 4.7) similar to observations from previous surveys, although even the main channel stations displayed higher counts over those observed during previous surveys.

One salinity value taken from the raw sewage displayed an elevated salinity value, indicating that saltwater intrusion may play a role in determining FC counts observed from the outfall (Table 1, survey #2, station 2).

## Conclusion

The Class A water quality standard for fecal coliform bacteria generally was not being met in the Willapa River at Raymond, Washington. Fecal coliform levels exceeded the standard in the north fork and in the south fork on which the City of Raymond raw sewage discharge is located. Below the confluence of the two forks (R.M. 7.2), fecal coliform levels appeared to drop off substantially so that at the station farthest downstream (R.M. 4.7), the fecal coliform standard was sometimes met even though upstream it was not (Table 1). The decline in FC values suggests that self-purification processes within the river are effectively removing the bacteria. Possible factors in this process are: settling out; bacterial dieoff; dilution; or possibly some other mechanism.

However, due to the oysters' ability to concentrate bacteria in their tissue to levels many times that found in the surrounding waters, even slight increases in FC counts in the receiving waters of Willapa Bay would be undesirable. To fully address the potential for contamination of oyster beds by slight increases in fecal coliform counts in the lower Willapa River would require an extensive survey of the bay which was beyond the scope of this study.

DC:cp

Attachments

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Table 1. Water quality data gathered during the Raymond outfall and Willapa River survey, spring 1982.
NOTE: Stations are listed from upstream to farthest downstream locations.

Flood Tide survey (#1), April 13, 1982

| Station Number | River Mile1/ | F. Coliform (org/100 mL) | Salinity (o/oo) | Diss. Oxygen (mg/L) | Temp. (°C) |
|---|---|---|---|---|---|
| 1 S.F.2/ | 1.3 | 160 | 4/ | 11.1 | -- |
| 2 Marsh | 1.1 | 900 | 4/ | 11.3 | 6.3 |
| 3 S.F.2/ | 1.1 | 1,900 | 4/ | -- | -- |
| 4 S.F.2/ | 1.1 | 1,100 | 4/ | 11.4 | 6.4 |
| 5 Far shore S.F.2/ | 1.1 | 500 | 4/ | 11.3 | 6.6 |
| 6 Sewage Outfall | 1.0 | 32,000 | 4/ | -- | -- |
| 6 Sewage Outfall | 1.0 | 26,000 | 4/ | 8.5 | 7.7 |
| 7 Main Channel | 7.1 | 660 | 4/ | 11.6 | 6.3 |

Ebb Tide Survey (#2), April 21, 1982

| Station Number | River Mile1/ | F. Coliform (org/100 mL) | Salinity (o/oo) | Diss. Oxygen (mg/L) | Temp. (°C) |
|---|---|---|---|---|---|
| 1 Above Discharge S.F.2/ | 1.3 | 130 | 3.5 | -- | 10.3 |
| 2 Sewage Outfall | 1.0 | 45,000 | 5.1 | -- | 11.0 |
| 3 Discharge Ditch | 1.0 | 36,000 | -- | -- | -- |
| 4 Barge | .95 | 1,300 | 5.3 | -- | 9.6 |
| 5 East Shoreline | .9 | 35 | 5.2 | -- | 9.7 |
| 6 Hwy. Bridge S.F.2/ | .9 | 560 | -- | -- | -- |
| 7 S.F.2/ | .85 | 440 | -- | -- | -- |
| 8 S.F.2/ | .8 | 280 | -- | -- | -- |
| 9 S.F.2/ | .7 | 200 | 6.7 | -- | 10.0 |
| 10 R.R. Bridge S.F.2/ | .3 | 170 | -- | -- | -- |
| 11 Hwy. Bridge N.F.3/ | 7.8 | 96 | 6.9 | -- | 9.2 |
| 12 Main Channel | 7.1 | 39 | 9.6 | -- | 9.5 |
| 13 Main Channel | 7.1 | 11 | -- | -- | -- |

Quarter-Point Survey (#3), May 3, 1982

| Station Number | River Mile1/ | F. Coliform (org/100 mL) | Salinity (o/oo) | Diss. Oxygen (mg/L) | Temp. (°C) |
|---|---|---|---|---|---|
| 1-R Above Discharge S.F.2/ | 1.3 | 46* | -- | -- | -- |
| 1-M Above Discharge S.F.2/ | 1.3 | 46* | 0.0 | 11.7 | 10.0 |
| 1-L Above Discharge S.F.2/ | 1.3 | 31* | -- | -- | -- |
| Sewage Outfall (E) | 1.0 | 32,000 | -- | -- | -- |
| 2-A Discharge Ditch | 1.0 | 19,000 | -- | 2.9 | -- |
| 2-B Discharge Ditch | 1.0 | 21,000 | -- | -- | -- |
| 3-R R.R. Bridge S.F.2/ | .3 | 230 | -- | -- | -- |
| 3-M R.R. Bridge S.F.2/ | .3 | 320 | 4.1 | 10.2 | 11.1 |
| 3-L R.R. Bridge S.F.2/ | .3 | 220 | -- | -- | -- |
| 4-R N.F.3/ | 7.8 | 57 | -- | -- | -- |
| 4-M N.F.3/ | 7.8 | 50 | 3.4 | 10.2 | 11.0 |
| 4-L N.F.3/ | 7.8 | 56* | -- | -- | -- |
| 5-R Main Channel | 7.0 | 71 | -- | -- | -- |
| 5-M Main Channel | 7.0 | 66 | 6.8 | 10.1 | 11.4 |
| 5-L Main Channel | 7.0 | 50 | -- | -- | -- |
| 6-A Sewage Lagoon5/ | 7.2 | 320 | 5.3 | 10.3 | 11.2 |
| 6-B Sewage Lagoon | 7.2 | 150 | -- | -- | -- |
| 7-R Main Channel | 4.7 | 44* | -- | -- | -- |
| 7-M Main Channel | 4.7 | 31* | 10.6 | 10.2 | 11.6 |
| 7-L Main Channel | 4.7 | 20* | -- | -- | -- |

Quarter-Point Survey (#4), May 24, 1982)

| Station Number | River Mile1/ | F. Coliform (org/100 mL) | Salinity (o/oo) | Diss. Oxygen (mg/L) | Temp. (°C) |
|---|---|---|---|---|---|
| 1-R Above Discharge S.F.2/ | 1.3 | 680* | .7 | -- | 10.9 |
| 1-L Above Discharge S.F.2/ | 1.3 | 950* | -- | -- | -- |
| Bypass (b)6/ S.F.2/ | 1.1 | 2,300,000 | -- | -- | -- |
| Bypass (b) S.F.2/ | 1.1 | 2,400,000 | -- | -- | -- |
| 2-A Discharge Ditch | 1.0 | 220,000* | -- | -- | -- |
| 2-B Discharge Ditch | 1.0 | 200,000* | -- | -- | -- |
| 3-R R.R. Bridge S.F.2/ | .3 | 920* | 5.4 | -- | 13.4 |
| 3-M R.R. Bridge S.F.2/ | .3 | 670* | 5.9 | -- | 13.4 |
| 3-L R.R. Bridge S.F.2/ | .3 | 600 | 5.6 | -- | 13.5 |
| 4-R N.F.3/ | 7.8 | 410* | 5.2 | -- | 14.3 |
| 4-M N.F.3/ | 7.8 | 300* | 5.1 | -- | 14.3 |
| 4-L N.F.3/ | 7.8 | 420* | 5.2 | -- | 14.3 |
| 5-R Main Channel | 7.0 | 320* | 7.7 | -- | 14.3 |
| 5-M Main Channel | 7.0 | 300* | 7.6 | -- | 14.2 |
| 5-L Main Channel | 7.0 | 240 | 7.7 | -- | 14.3 |
| 6-A Sewage Lagoon | 7.2 | 300 | 7.1 | -- | 14.3 |
| 6-B Sewage Lagoon | 7.2 | 240 | 7.1 | -- | 14.1 |
| 7-R Main Channel | 4.7 | 96 | 12.7 | -- | 14.4 |
| 7-M Main Channel | 4.7 | 140 | 12.5 | -- | 14.3 |
| 7-L Main Channel | 4.7 | 150 | 12.5 | -- | 14.3 |

1/Note: River mileage (RM) values >2 pertain to the Main Channel; all other values refer to distance on the South Fork from the confluence of the North and South Forks.
2/S.F. = South Fork of the Willapa River.
3/N.F. = North Fork of the Willapa River.
4/Samples were discarded before laboratory analysis was completed.
5/Sewage lagoon seperate sewage treatment facility for Raymond see map (Figure 1) for location.
6/Riverview pump station bypass line observed during May 24, 1982 survey. Refer to WDOE memo (Clark, 1982).
-- = Data not collected.
* = Estimated

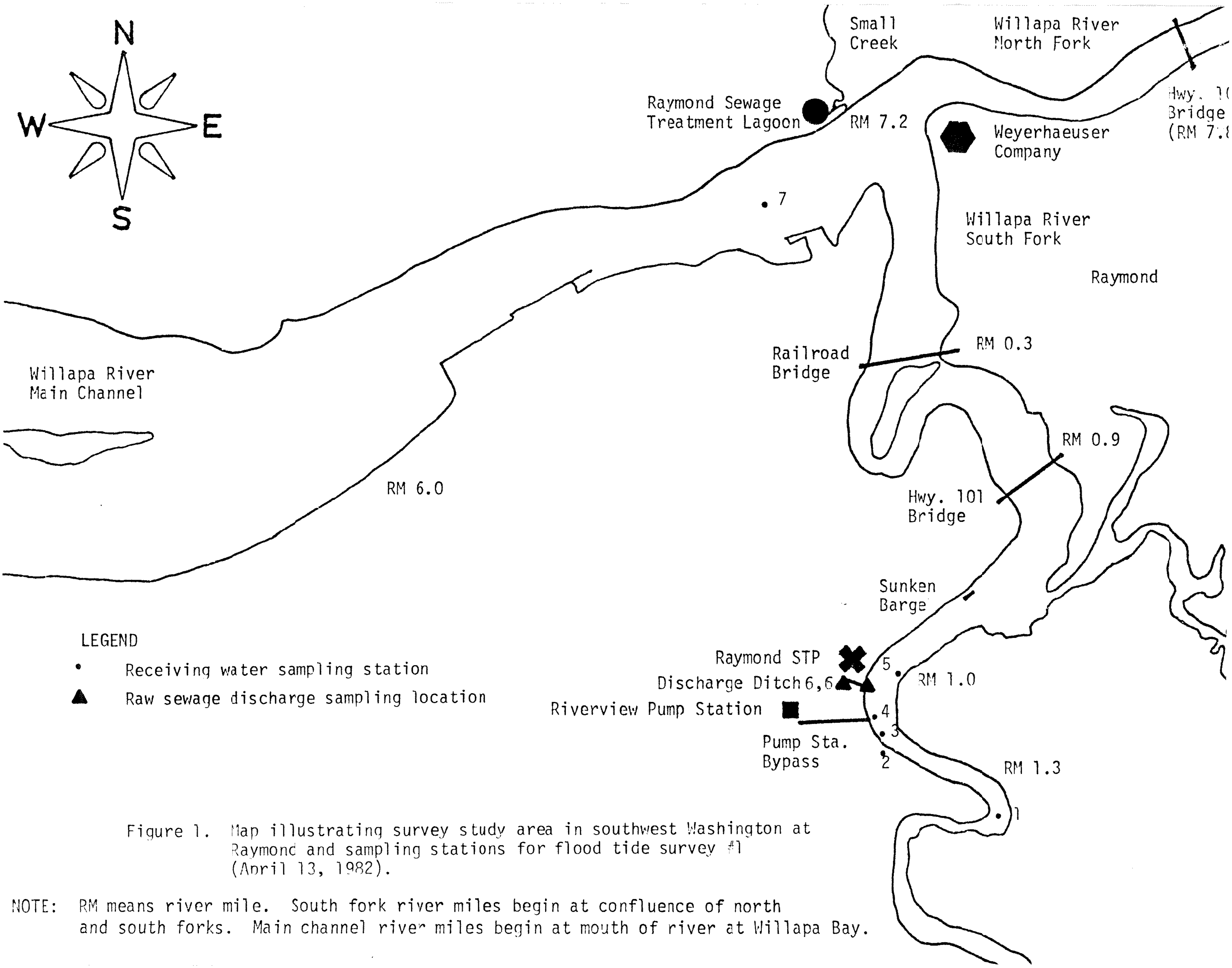


Figure 1. Map illustrating survey study area in southwest Washington at Raymond and sampling stations for flood tide survey #1 (April 13, 1982).

NOTE: RM means river mile. South fork river miles begin at confluence of north and south forks. Main channel river miles begin at mouth of river at Willapa Bay.

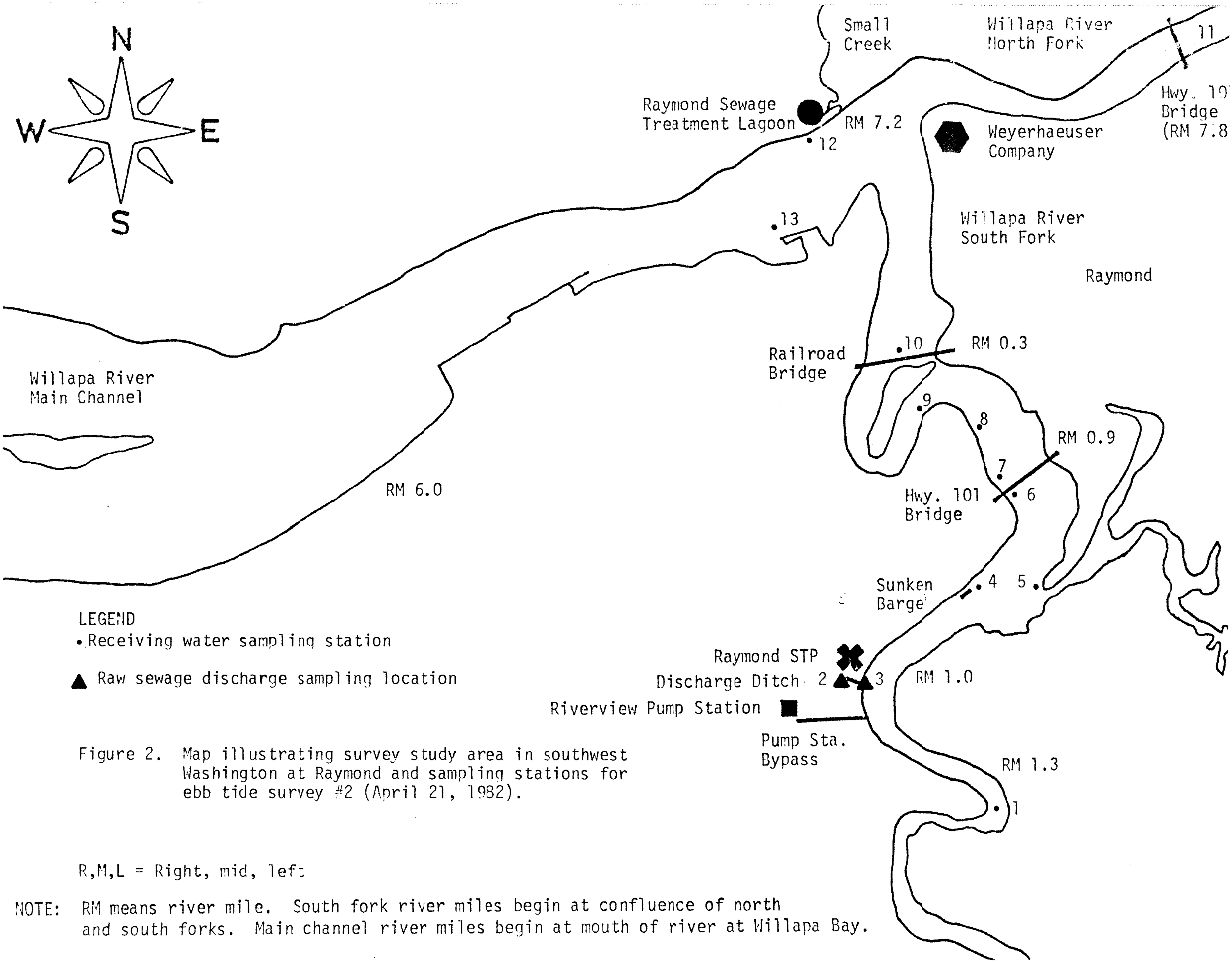


Figure 2. Map illustrating survey study area in southwest Washington at Raymond and sampling stations for ebb tide survey #2 (April 21, 1982).

R,M,L = Right, mid, left

NOTE: RM means river mile. South fork river miles begin at confluence of north and south forks. Main channel river miles begin at mouth of river at Willapa Bay.

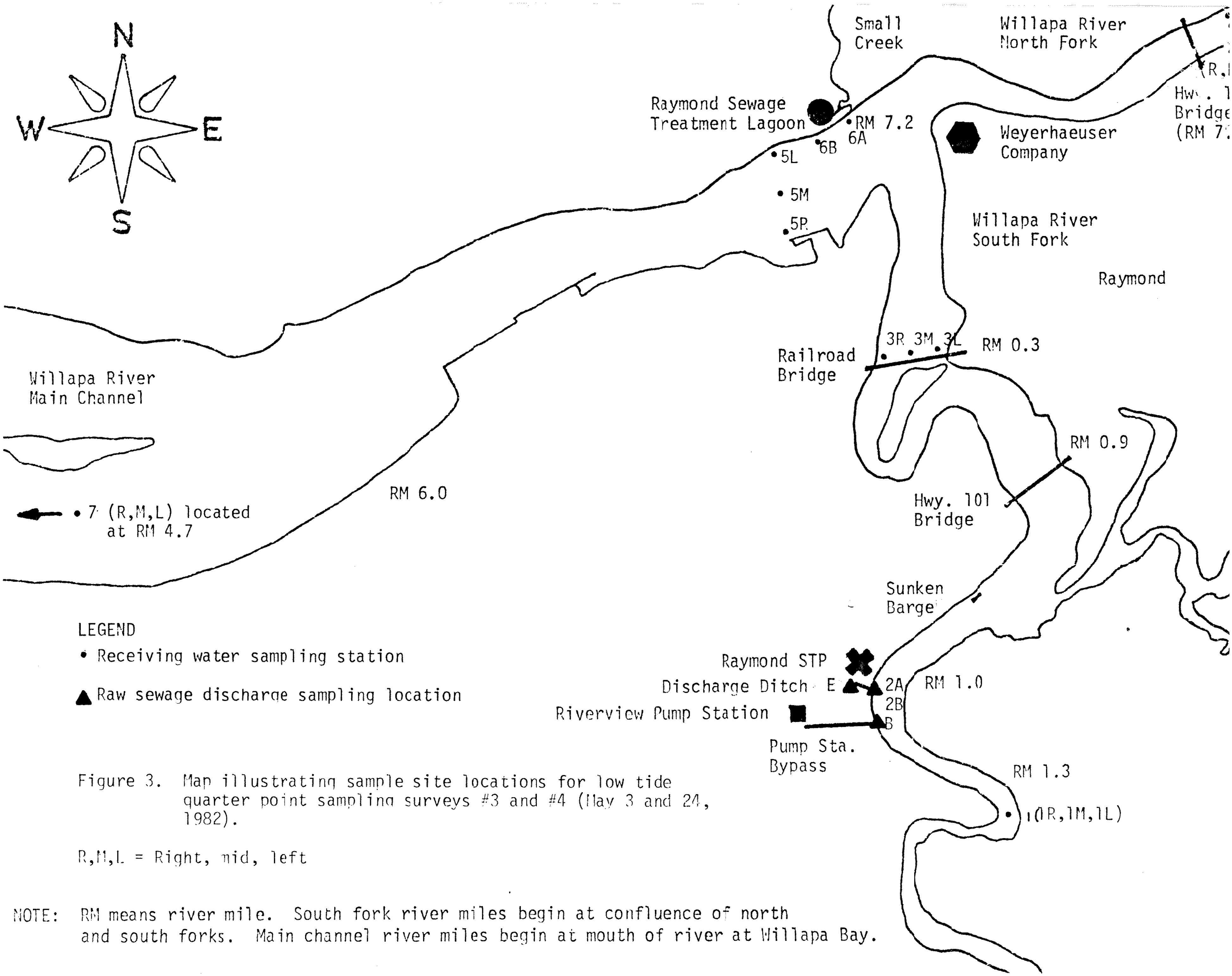


Figure 3. Map illustrating sample site locations for low tide quarter point sampling surveys #3 and #4 (May 3 and 24, 1982).

R,M,L = Right, mid, left

NOTE: RM means river mile. South fork river miles begin at confluence of north and south forks. Main channel river miles begin at mouth of river at Willapa Bay.